博士学位論文内容の要旨

氏　　名	張（チョウ）　維珊（イサン）
所　　属	人間健康科学研究科　人間健康科学専攻
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学位論文題名	Absorbed dose to water dosimetry for heavy charged particle beams using solid-state luminescence dosimeters （固体蛍光線量計を用いた重荷電粒子線水吸収線量計測に関する研究）
論文審査委員	主査　教　授　齋藤　秀敏 委員　教　授　眞正　浄光 委員　教　授　榮　武二（筑波大学）

【論文の内容の要旨】

Dose verification before treatment is important for radiotherapy and it includes the comparison of point dose and the comparison of two-dimensional (2D) dose distribution. As heavy charged particle (HCP) therapy facilities increased, the interest and the demand of dosimetry system for HCP beams increased and many reports concerned with the feasibility of the dosimeter in HCP beams. The radiophotoluminescence glass dosimeter (RGD) is widely used for conventional radiotherapy because they have many advantageous such as high reproducibility, reusable, and easy to handle. Besides point dose measurement, 2D dose measurement is also desirable for verifying the complex dose distribution in HCP radiotherapy. Recently, a tissue equivalent slab-type thermoluminescence dosimeters (TLD) based on the TL phosphor $Li_3B_7O_{12}$:Cu has been developed to verify the dose distribution in 2D.

However, the problem of LET dependent response are not solved. To use the solid-state luminescence dosimeters in HCP dosimetry a comprehensive investigation and a method that take into account the LET dependence are necessary.

In regards to RGDs, the LET dependence of RGD in proton/carbon beam have been investigated experimentally and the Monte Carlo simulation toolkit Geant4 was used to obtain the energy spectra, particle fluence, and LET at the measurement point. For practical use, the residual range R_{res} was used as a quality index to determine the correction factor for radiophotoluminescence (RPL) efficiency $\varepsilon_{k,\gamma}^{\mathrm{RGD}}$. The feasibility of RGD was evaluated by comparing D_{w} measured by RGD $D_{\mathrm{w}}^{\mathrm{RGD}}$ and ionization chamber $D_{\mathrm{w}}^{\mathrm{IC}}$ at difference depth in therapeutic proton/carbon beams.

In regards to the results of RGD in proton dosimetry, $D_{\mathrm{w}}^{\mathrm{RGD}}$ shows good agreement with $D_{\mathrm{w}}^{\mathrm{IC}}$ and the relative difference between $D_{\mathrm{w}}^{\mathrm{RGD}}$ and $D_{\mathrm{w}}^{\mathrm{IC}}$ are within 3 % except where R_{res} is less than 1 cm. In regards to the RGD in carbon dosimetry, large difference between $D_{\mathrm{w}}^{\mathrm{RGD}}$ and $D_{\mathrm{w}}^{\mathrm{IC}}$ was observed in modulated carbon beam. Furthermore, it is clarified that $\varepsilon_{k,\gamma}^{\mathrm{RGD}}$ estimated by proton beam is lower than that by carbon beam even they have same LET.

According to the results demonstrated above, RGD can be used as dose verification tool and postal audit dosimeter for proton therapy. And the results of LET dependence of $\varepsilon_{k,\gamma}^{\mathrm{RGD}}$ between carbon and proton is clarified which is helpful for RGD in carbon dosimetry.

The relationship between TL-efficiency $\varepsilon_{k,\gamma}^{\mathrm{TLD}}$, relative HTR $HTR_{k,\gamma}$, and LET for $Li_3B_7O_{12}$:Cu was investigated and the $\varepsilon_{k,\gamma}^{\mathrm{TLD}}$ as a function of $HTR_{k,\gamma}$ was derived with an attempt to measure D_{w} without LET information. The feasibility of the HTR method in

therapeutic carbon beams was evaluated by comparing the D_w measured by $Li_3B_7O_{12}$:Cu D_w^{TLD} and D_w^{IC} at difference depth in the modulated carbon beam.

As a result, the maximum of dose difference between D_w^{TLD} and D_w^{IC} was decreased from 50 % to 30 % after the HTR correction. Therefore it is concluded that the accuracy of D_w estimation in carbon beams was improved by HTR method, and the usefulness of slow heating method was revealed which is helpful for $Li_3B_7O_{12}$:Cu in HCP dosimetry.

In this thesis, with an aim of using solid-state luminescence dosimeter in HCP dosimetry, the methods that take into account the LET dependence were proposed and the feasibility were evaluated.